DOE Sensors & Automation 2005 Annual Portfolio Review

Robotically Enhanced Advanced Manufacturing Concepts to Optimize Energy, Productivity, and Environmental Performance

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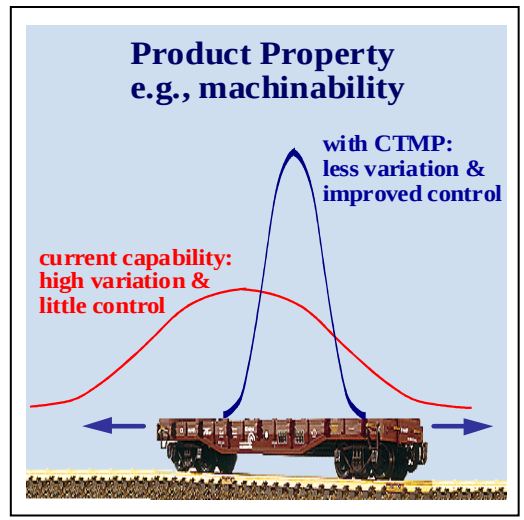
Laser Ultrasonic Tube Wall Gauge

- **$3.4 million project funded by the U.S. DoE & The Timken Company**
- **Project duration May ’99 – Jul ’02**
- **Aim - to sense tube wall variation**
- **Technology by NRC-IMI developed into mill device deployed at Timken**
- **1,000,000th tube inspected Aug ’04**
- **Savings from reduced mill set-up time and less scrap & rework**
- **System commercially available**

Controlled Thermo-Mechanical Processing

- **$18.4 million project funded by the U.S. DoE & The Timken Company**
- **Project duration Sep ’99 – Aug ’05**
- **Aim – to control product variation**
- **Model developed to predict tube microstructure for given process trajectory to meet product target**
- **Various processing recipes developed**
- **Savings from reduced post-processing and reduced tool wear in machining**



Project Description

- **Need**
  - The emergence of manufacturing in low labor cost countries has put additional pressure on American manufacturing cost competitiveness. Robotic and advanced thermal treatment technologies offer American industry the opportunity to meet the manufacturing challenges.
  - Continued, rapid growth of manufacturing in low labor cost countries with the disappearance of those that cannot successfully compete with technology support.

Project Description

- **Goal**
  - Construct an advanced, low-volume manufacturing line for the production of anti-friction bearing races that can compete based upon technological advancements in energy usage, productivity and environmental performance.
- **Core Technology**
  - Advanced induction thermal treatment process
  - Advanced light weight robotics
  - Advanced, high temperature, thermal treatment robotics

Project Description

- **Novel/Transformational Element(s)**
  - Energy-efficient induction heating processes, which operate on demand, will replace continuously heated, energy over-sized furnaces.
  - Robotics, including low mass gantry robotics, will tend the processes thereby reducing manual repetitive labor.

- **Initial Industry for Application**
  - End-use application: thermal treatment of metal parts

Project Description

- **Key Project Deliverable(s)**
  - Analysis of potential for energy savings for bearing races and other heat treated, metal products
  - Analysis of potential for reduction of environmental impact
  - Analysis of potential for productivity increases

Barriers and Pathways

- **Barrier**
  - Uniform induction heating which does not require part specific tooling across a full range of diameters, widths, cross sections
- **Pathway**
  - Design of experiment test matrix will establish size range of tooling, coils and heating recipes required for full range of product geometry
- **Barrier**
  - Shielding that minimizes electromagnetic flux leakage
- **Pathway**
  - Search and test shielding EMF shielding alternatives

Barriers and Pathways

- **Barrier**
  - Ability to sense and grip parts that are hot (subject to geometric distortion) or at ambient temperature, clean and dry or dirty and wet
- **Pathway**
  - Optimization of gripper actuation forces and minimization of heat transfer from heated product to the grippers and ambient air
- **Barrier**
  - Ability to accurately position parts in assets that must reliably function in harsh metal removal environments
- **Pathway**
  - Development of low cost, low mass (high speed), energy efficient robotics which utilize sensors to accurately load parts

Energy Savings

- **How will energy be saved?**
  - Energy-efficient induction heating processes, which operate on demand, will replace continuously heated, energy over-sized furnaces
  - Scrap reduction will also save energy
- **Assumptions used in calculation**
  - Capacity is limited to a five day schedule to protect the customer
  - Typical gas and electric furnaces operate at approximately 20% efficiency
- **How much energy will be saved?**
  - Estimated 200,000 – 350,000 kW-hrs per line (28 to 50% energy reduction) from power on demand and induction energy efficiency

Other Important Metrics

- **Productivity (flow time, labor hours)**
- **Environment (greenhouse gas emissions, generation of liquid and solid wastes)**
- **Health and Safety (repetitive motion injuries associated with manual manufacturing operations)**

Accomplishments to Date

- **Development of research prototype for induction heating of bearing races**
- **Specification, purchase, and installation of major process assets**
- **Purchase and installation of commercial gantry robot for thermal treatment cell**
- **Design and fabrication of low cost, low mass, high placement accuracy gantry robot for finish cell**

Next Project Steps

- **Internal proof of concepts by simulating bearing race production line operation**

Future Milestones

#	Description of Milestone	FY date
1	Preliminary Improvement calculations	12th month ‘05
2	Specify, purchase and install secondary assets and support equipment	12th month ‘05
3	Trial run of major assets	12th month ‘05
4	Integrate advanced thermal treatment assets to conventional gantry robot	12th month ‘05
5	Begin integration of finish assets to light-weight, high-speed gantry robot	12th month ‘05
6	Evaluate and preliminary development of mfg. execution and automation systems	12th month ‘05
7	Integrate line assets to manufacturing execution and automation systems	12th month ‘06
8	Model optimized and balanced line	12th month ‘06
9	Trial implementation in production facility	12th month ‘07
10	Demonstrate proprietary thermal treatment energy efficiency	12th month ‘07

Continuation after ITP-Sponsored Project

- **Proof of applicability of generalized thermal treatment of a variety of metal parts**

Value Proposition for End User

- **Industry payback will be based upon ratio of energy savings and productivity increases to equipment capital cost**

Commercialization Plan

- **Develop proof of concept for end-use application: thermal treatment of metal parts**
- **Develop licensing of technology opportunities**

Commercial/Technical Risks Remaining

- **Development of low cost power supply to maximize savings to capital ratio**
- **Development of minimum EMF leakage**
- **Ability to accurately position parts in assets that must reliably function in harsh metal removal environments**
- **Ability to sense and grip parts that are hot (subject to geometric distortion) or at ambient temperature, clean and dry or dirty and wet**